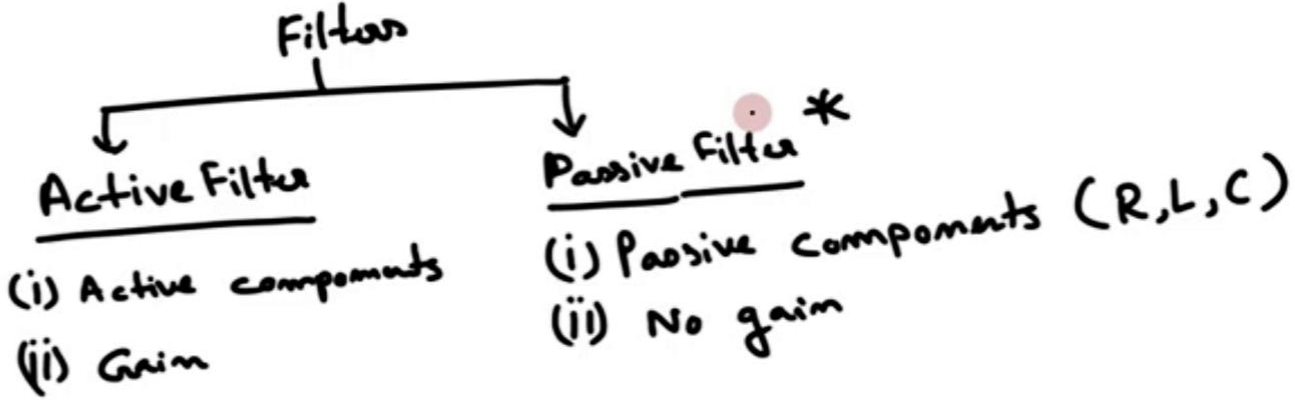
Passive Filters



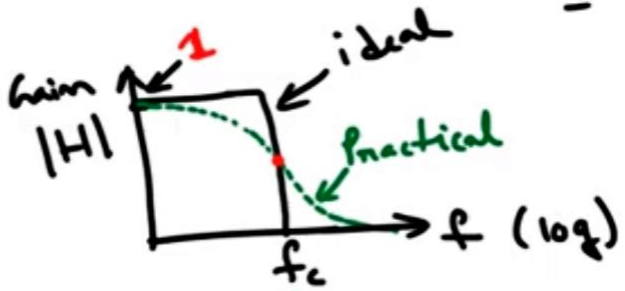
Passive Filters

$$\text{Gain} = \frac{V_{out}}{V_{in}}$$

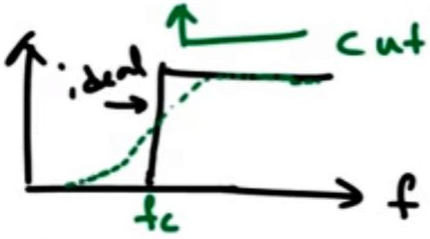
$$H = \frac{V_{out}}{V_{in}}$$

Passive filter

(i) Low pass filter (LPF)

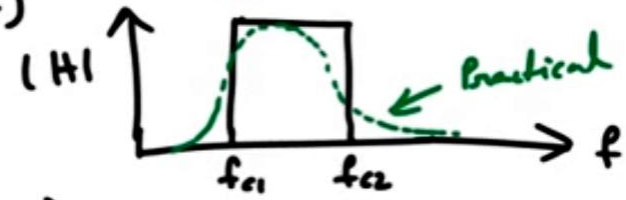


(ii) High Pass filter (HPF)



$$P \propto V^2$$

(iii) Band pass filter (BPF)



$$V_{out} = \frac{1}{\sqrt{2}} V_{in}$$

$$|H| = \frac{1}{\sqrt{2}}$$

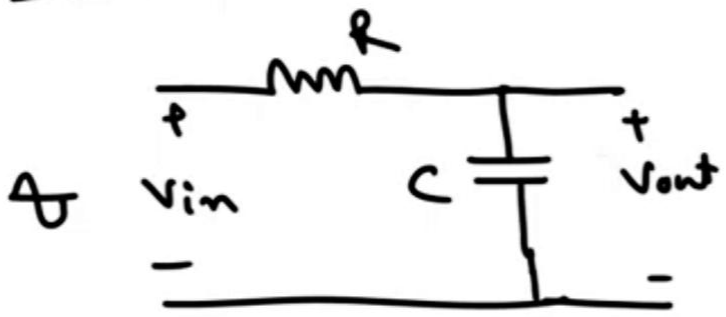
'f_c'

(iv) Band-Stop Filter (BSF)
Band-Reject

Passive Filters

dB

Low Pass Filter (LPF)



$$V_{out} = \frac{Z_c}{R + Z_c} V_{in} = \frac{\frac{1}{j\omega C}}{R + \frac{1}{j\omega C}} V_{in}$$

$$= \frac{1}{1 + j\omega RC} V_{in}$$

$\omega = 2\pi f$

f_c

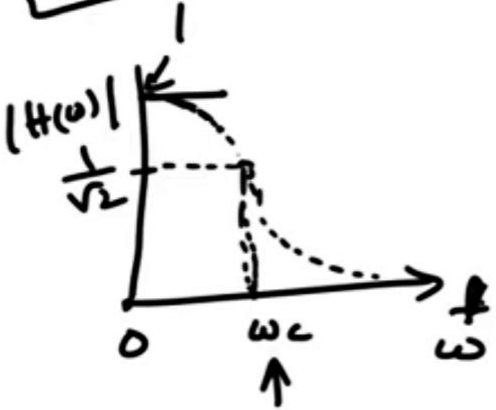
$$H = \frac{V_{out}}{V_{in}} = \frac{1}{1 + j\omega RC}$$

$$|H| = \frac{1}{\sqrt{1 + \omega^2 R^2 C^2}}$$

$$\omega = \frac{1}{RC}$$

$$|H(\omega)| = \frac{1}{\sqrt{2}} \rightarrow \text{cut-off}$$

ω_c = cut-off freq. $= \frac{1}{RC}$



Passive Filters

$|H(\omega)| = \frac{1}{\sqrt{1+\omega^2 R^2 C^2}}$ ← $\left|\frac{V_{out}}{V_{in}}\right|$

$10 \log\left(\frac{P_{out}}{P_{in}}\right) = 10 \log\left(\frac{V_{out}^2}{V_{in}^2}\right)$

$= 20 \log\left(\frac{V_{out}}{V_{in}}\right)$

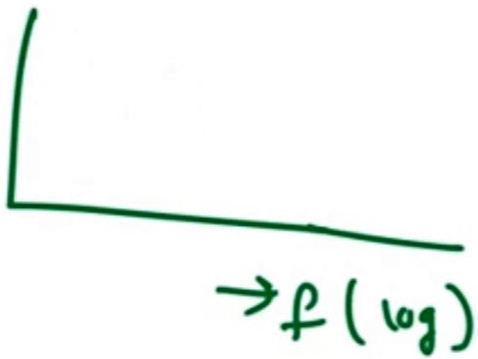
dB → $20 \log \frac{1}{\sqrt{1+\omega^2 R^2 C^2}}$ = ??

$= 20 \log \frac{1}{\sqrt{1+1}}$

$\omega = \omega_c = \frac{1}{RC}$

Cut-off freq.

$\longleftrightarrow$ = − 3 dB freq.



Passive Filters

V_o Phase ??

$$|H(\omega)|_{dB} = 20 \log \frac{1}{\sqrt{1+\omega^2 R^2 C^2}}$$

at $\omega = 0$, $|H(\omega)|_{dB} = 0$

$\omega_c = 1/RC$

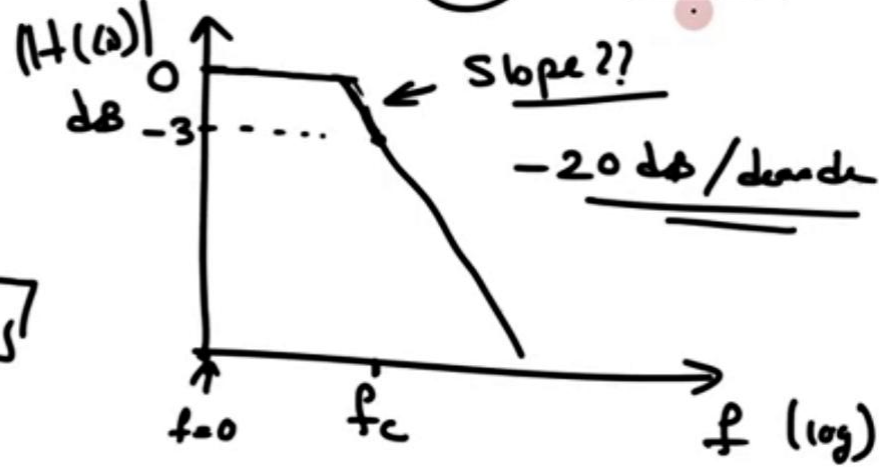
$\omega = \omega_c$, $|H(\omega)|_{dB} = -3$ dB

$$|H(\omega)|_{dB} = 20 \log \frac{1}{\sqrt{1+\left(\frac{\omega}{\omega_c}\right)^2}}$$

$\omega = 10\omega_c$ ⟷ decade

$$|H(\omega)|_{dB} = 20 \log \frac{1}{\sqrt{1+\left(\frac{10}{1}\right)^2}}$$

$$= 20 \log\left(\frac{1}{10}\right) = -20 \text{ dB}$$



Slope = −20 dB/decade

Passive Filters

$$H(\omega) = \frac{1}{1 + j\omega RC}$$

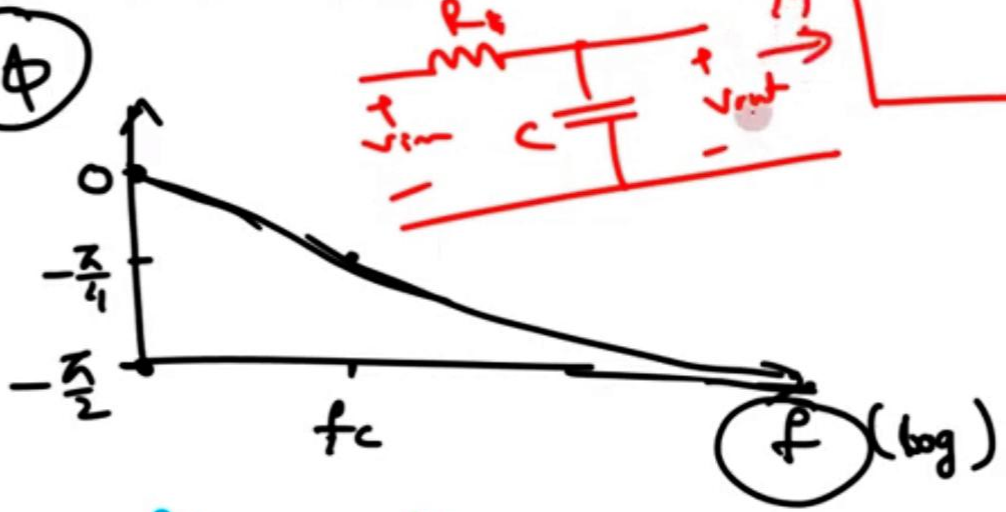
$$\Phi = -\tan^{-1}\left(\frac{\omega RC}{1}\right)$$

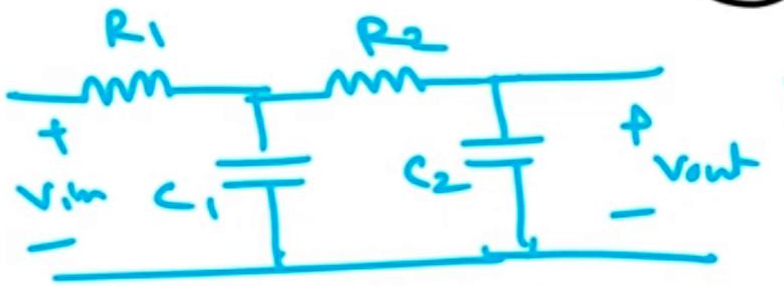
$$\text{phase } \Phi = -\tan^{-1}(\omega RC)$$

$\omega = 0, \quad \Phi = 0$

$\omega = \omega_c = \frac{1}{RC}, \quad \Phi = \frac{\pi}{4}$

$\omega \to \infty, \quad \Phi = -\frac{\pi}{2}$

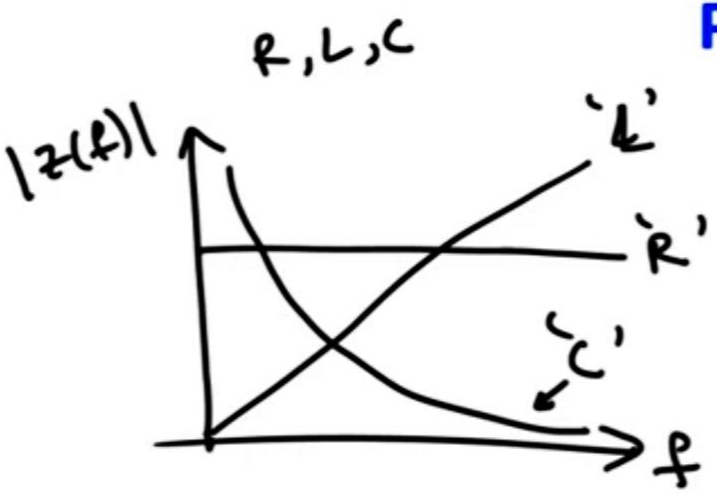




H.W.

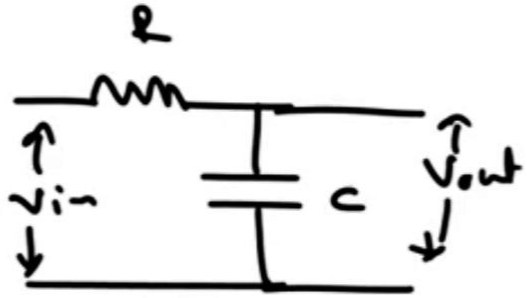
Type ?? Slope ?? f_c ??

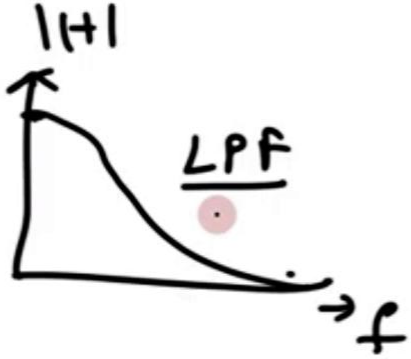
Passive Filters



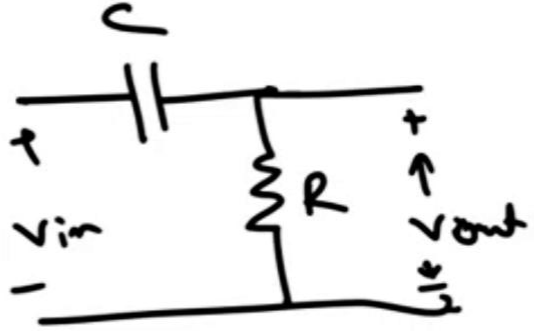
$$X_L = j\omega L$$

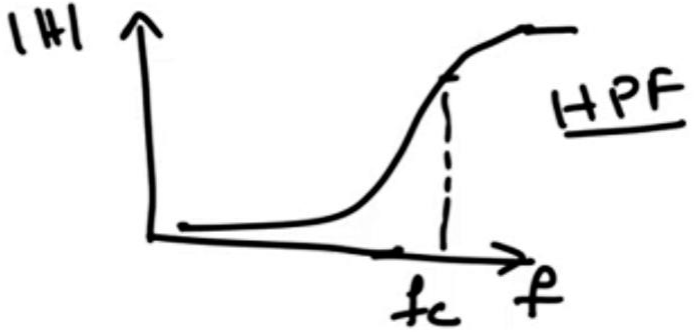
$$X_C = \frac{1}{j\omega C}$$





Passive Filters

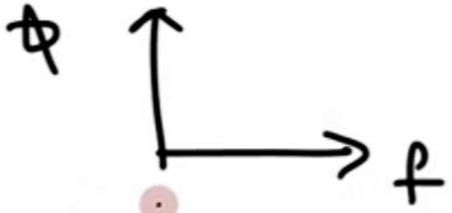




$$\frac{V_{out}}{V_{in}} = \frac{R}{R + \frac{1}{j\omega C}}$$

$$= \frac{Rj\omega C}{Rj\omega C + 1}$$

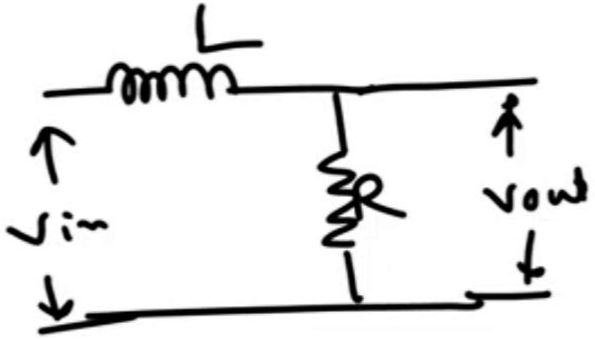
$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{R\omega C}{\sqrt{1 + R^2\omega^2 C^2}}$$

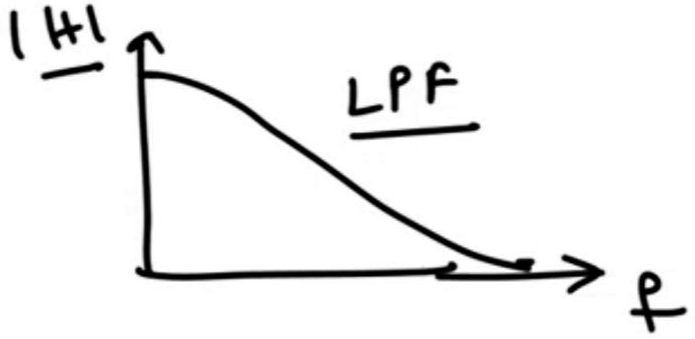


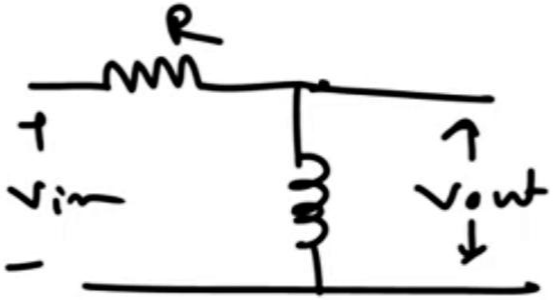
; $\omega = \frac{1}{RC}$, $\left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{\sqrt{2}}$

ω_c

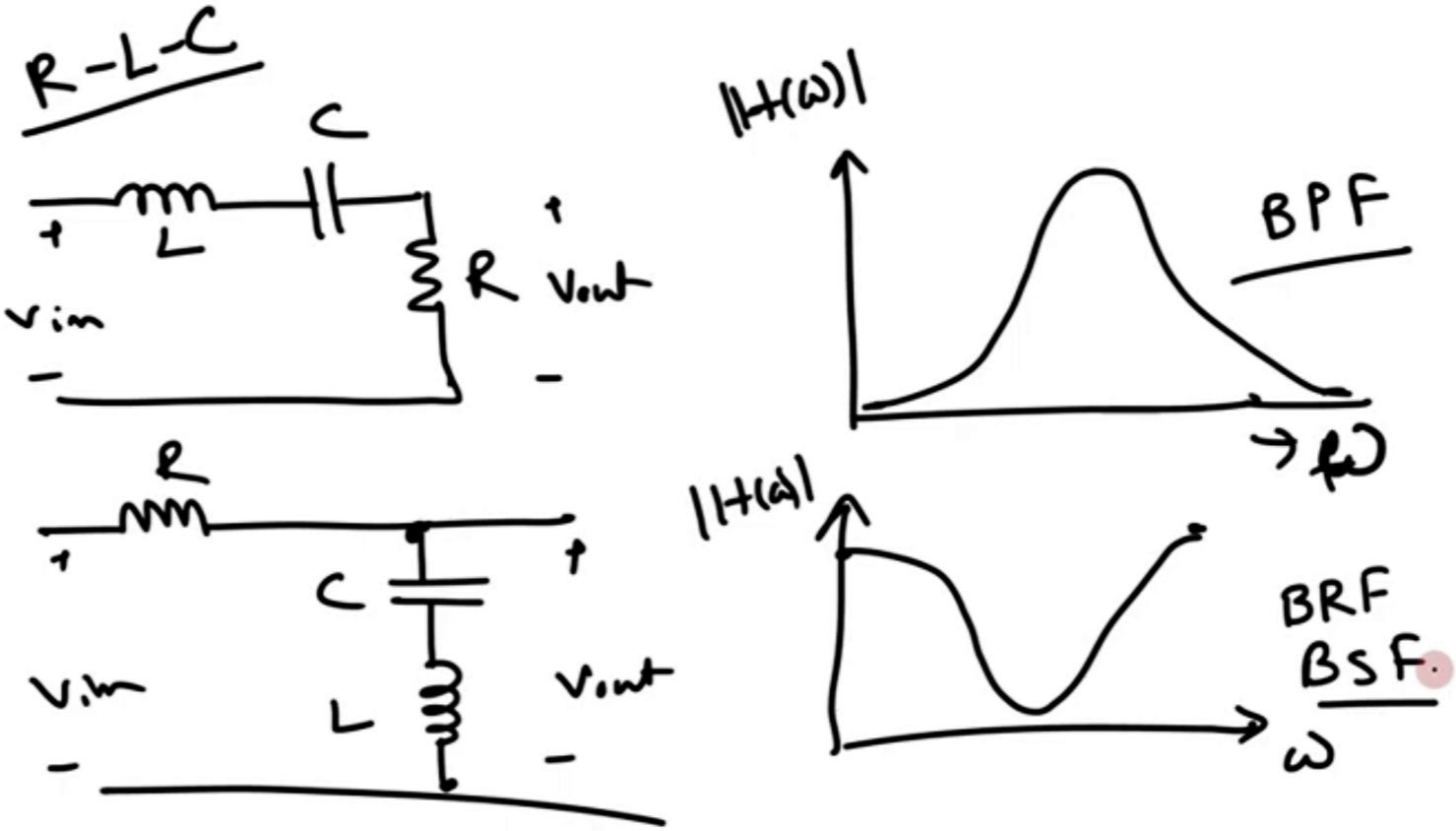
Passive Filters



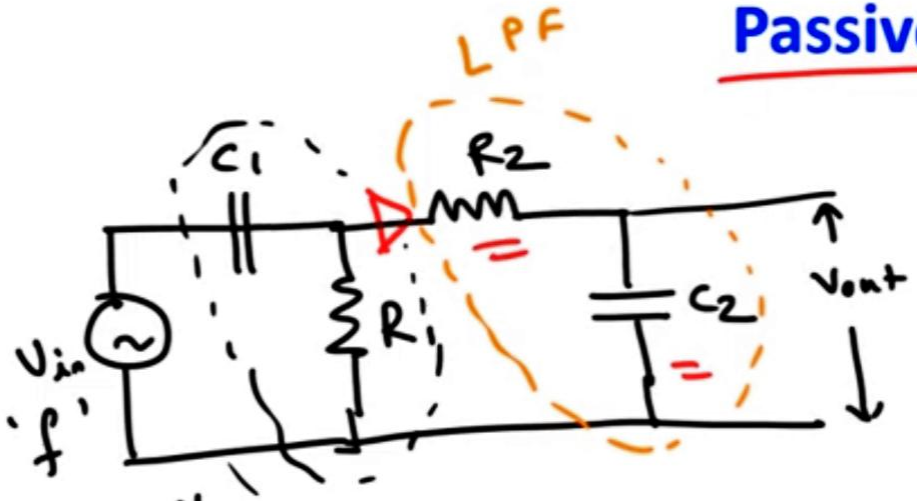




Passive Filters



Passive Filters



LPF → f_{c2}

HPF → f_{c1}

$f_{c2} > f_{c1}$